

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization International Bureau



(43) International Publication Date  
23 October 2003 (23.10.2003)

PCT

(10) International Publication Number  
**WO 2003/088364 A3**

(51) International Patent Classification<sup>7</sup>: **H01L 29/78**, 29/10, 29/36

(21) International Application Number: PCT/IB2003/001465

(22) International Filing Date: 10 April 2003 (10.04.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 0208833.4 18 April 2002 (18.04.2002) GB

(71) Applicant (for all designated States except US): **KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]**; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **PEAKE, Steven, T.** [GB/GB]; Philips Intellectual Property & Standards, Cross Oak Lane, Redhill, Surrey RH1 5HA (GB).

(74) Agent: **SHARROCK, Daniel, J.**; Philips Intellectual Property & Standards, Cross Oak Lane, Redhill, Surrey RH1 5HA (GB).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

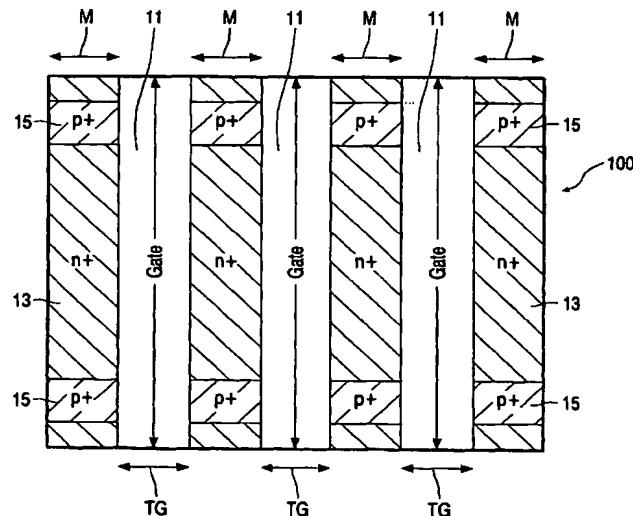
Published:

— with international search report

(88) Date of publication of the international search report:  
26 February 2004

[Continued on next page]

(54) Title: TRENCH-GATE SEMICONDUCTOR DEVICES



(57) Abstract: A trench-gate vertical power transistor in which the trench-gates (11) are parallel stripes which extend across the active area (100). Source regions (13) and ruggedness regions (15) extend to a source contact surface as alternating stripe areas having a width perpendicular to and fully between each two adjacent parallel stripe trench-gates (11). The ruggedness regions (15) are more heavily doped than the source regions and this enables an increased length of the source regions with a consequent reduction in specific resistance of the transistor. For example, the mesa width (13,15) and the trench-gate (11) width may both be about 0.4μm, the ruggedness region (15) length may be about 1μm and the source region (13) length may be about 20μm. The doping concentration of the p type ruggedness regions (15) may be approximately 10 times greater than the doping concentration of the n type regions(13), for example about 10<sub>21</sub> cm.<sup>-3</sup> and about 10<sub>20</sub> cm.<sup>-3</sup> respectively.

WO 2003/088364 A3



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

13 OCT 2003

## INTERNATIONAL SEARCH REPORT

PCT/IB 03/01465

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01L29/78 H01L29/10 H01L29/36

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|------------|---|-----------------------|
| A          | US 5 072 266 A (BULUCEA C ET AL)<br>10 December 1991 (1991-12-10)<br>cited in the application<br>column 3, line 63 -column 4, line 27;<br>figures 2A,3A-3B<br>---   | 1                     |
| A          | EP 0 755 076 A (MITSUBISHI ELECTRIC CORP)<br>22 January 1997 (1997-01-22)<br>page 11, line 36 - line 39; figures 1-3<br>page 12, line 23 - line 53; figure 4<br>--- | 1                     |
| A          | EP 0 199 293 A (GEN ELECTRIC)<br>29 October 1986 (1986-10-29)<br>abstract; figures 1-5<br>-----   | 1                     |

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

## ° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

21 November 2003

Date of mailing of the international search report

02/12/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Morvan, D

## INTERNATIONAL SEARCH REPORT

PCT/IB 03/01465

| Patent document cited in search report |   | Publication date |  | Patent family member(s)   | Publication date   |
|--|---|------------------|--|---|--|
| US 5072266                             | A | 10-12-1991       | PT<br>US<br>US                                     | 92740 A ,B<br>5298442 A<br>6627950 B1   | 29-06-1990<br>29-03-1994<br>30-09-2003   |
| EP 0755076                             | A | 22-01-1997       | JP<br>JP<br>DE<br>EP<br>EP<br>EP<br>KR<br>US<br>US | 3384198 B2<br>9036362 A<br>69629251 D1<br>1233457 A2<br>1237201 A2<br>0755076 A2<br>250350 B1<br>5801408 A<br>5960264 A | 10-03-2003<br>07-02-1997<br>04-09-2003<br>21-08-2002<br>04-09-2002<br>22-01-1997<br>01-04-2000<br>01-09-1998<br>28-09-1999 |
| EP 0199293                             | A | 29-10-1986       | DE<br>EP<br>JP<br>JP<br>KR                         | 3677627 D1<br>0199293 A2<br>6093511 B<br>61281557 A<br>9007044 B1   | 04-04-1991<br>29-10-1986<br>16-11-1994<br>11-12-1986<br>27-09-1990   |